A Housing Energy Management Program Report

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IMPROVED EFFICIENCY DOMESTIC HOT WATER TANK FIELD STUDY - INSTALLATION REPORT - REPORT NO. 8A

UNDERTAKEN JOINTLY BY THE ONTARIO MINISTRIES OF MUNICIPAL AFFAIRS AND HOUSING AND ENERGY UNDER THE HOUSING ENERGY MANAGEMENT PROGRAM (H.E.M.P.)

PREPARED FOR
THE ONTARIO MINISTRY OF MUNICIPAL AFFAIRS AND HOUSING
HOUSING RENOVATIONS
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BY
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SUMMARY

In June 1983, the Ontario Ministry of Municipal Affairs and Housing entered into discussion with Union Gas Limited concerning the possibility of a joint research project to study high efficiency heating equipment. As a result of these talks, an agreement to field test two improved efficiency water heaters was reached. Each unit is monitored relative to a conventional unit of comparable capacity at the same site. Having completed the installation and commissioning of two such water heaters, this report addresses the details of the installations and the findings to date.

Both water heaters are currently operating and are being monitored. Test results are expected upon completion of one year of operation.

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1.0 INTRODUCTION

1.1 Study Agreement

Union Gas Limited and the Ministry of Municipal Affairs and Housing share a mutual interest in the area of energy conservation and more efficient appliances.

Improved Efficiency domestic water heaters have recently entered the residential heating equipment market. Due to their relative newness and the lack of field evaluation data, it was decided to study their performance in realistic field installation tests.

The Ministry of Municipal Affairs and Housing with funding through the Ministry of Energy HEMP program, and Union Gas, entered into an agreement to field test two improved efficiency water heaters. The objectives of the study were "to assess the energy savings, performance and economics through field testing of two improved efficiency water heaters on a retrofit basis in Southwestern Ontario". The improved efficiency units were also to be evaluated by comparison with equivalent capacity conventional units.

1.2 Selection of Test Locations

The basic criteria used to select possible sites at which the water heaters would be tested was that the locations must be representative of a 'typical' installation. Site criteria are outlined in Appendix A. A further concern was that the occupant water load requirement be once again 'typical'. The minimum family size for each location was subsequently set at three in order to fulfill these requirements.

One location selected was a detached, full basement, single storey, single family home with four (4) occupants. The existing conventional hot water heating system was a new 10.55 KW, 151.4 litre gas fired unit. The test unit was simply set alongside the existing unit and tied into the existing water piping system.

The second location was a detached, full basement, single storey ranch style home housing a family of four (4). The test unit will be compared with an equivalent load capacity 151.4 litre, 2-3 KW bank electric unit. For site details and equipment specifications please refer to Appendix A.

2.0 WATER HEATER OPERATION

Although similar to the conventional gas-fired water heater the distinguishing features of the improved efficiency unit include greater heat exchange surface area, a more effective anode giving better tank protection, bottom cold water inlet with optional top entry, and injector to distribute solids evenly in the tank. The standby losses are also reduced due to double thickness insulation. According to the manufacturer, because of the higher efficiency characteristics, the water heater can be operated at a lower input for equal supply of water than conventional units.

Canadian Gas Research Institute research on the new heaters have shown thermal efficiencies of approximately 82% with 3.5% standby losses. This compares with 70% thermal efficiency and 6.3% standby losses quoted values for conventional, standard model heaters.

3.0 FIELD TESTING PROCEDURE

In establishing a field test methodology, a consensus exists in that a flip/flop procedure is currently the best technique for energy consumption evaluation. The method itself involves operation of both the existing equipment and test equipment for alternate periods of time. As such, the equipment is connected in parallel with appropriate metering. For the purpose of this study, a one week cycling period was chosen.

A series of data was to be recorded upon switching from one water heater to the other. Essentially, one is looking to determine the total energy consumption and gallons of water consumption as compared to the Energy delivered to the house. Metering requirements included a gas submeter, an electric submeter, and a BTU meter (see Appendix B).

For test consistency, both units at each test site were set to approximately the same operating temperature. Outlet (delivery) water temperature was not used as a common gauge for comparison between units because of variability due to stacking effects. The units were therefore normalized by first starting them up with the tank full of cold water. After reaching set temperature and first shut-off, a temperature reading was taken from the drain valve at the bottom of each tank with the cold water valve closed. Adjustments in the temperature setting were then made and the procedure repeated until both the test and conventional units were at approximately the same first shut-off temperature.

A one hour warm up period before recording data was prescribed at the start up of each water heater during the flip/flop. This was to ensure that test conditions were representative of normal domestic operation, where the units would not be regularly shut down and restarted as required in the test procedure. Consequently, the energy consumption data for each initial start up period is not considered in this study analysis on the

grounds that this cold water recovery energy data is not representative of regular operation of a domestic hot water unit.

4.0 INSTALLATION FEATURES

4.1 General Considerations

The improved efficiency units do not include any major installation differences relative to the conventional gas water heaters. To provide for as typical an installation as possible, the contractor(s) were supplied with the manufacturer's instructions as enclosed with the water heaters and were given only limited instruction and supervision during their work (See Appendix C). Detailed instructions were given with any specific test requirements and metering to insure correct installation and recording accuracy. Both installations were awarded to local contractors whom we felt were representative of the industry. Such individuals are invaluable in providing constructive feedback as to installation procedures and equipment operation.

4.2 Sites

Both site installations were conventional in all respects. No modifications were imposed by space limitations or existing equipment, thereby making the installations very straight forward. Note that a water softener system was added to Site I, however its influence is estimated as being negligible in this study.

4.3 Operation

Aside from the installation requirements themselves, a more important concern was realized in the actual matching of the test and conventional water heaters. In matching the performance of each water heater particular attention was given to rated volumetric capacity. The energy input could not be compared in this case since a feature of the improved efficiency water heater is a lower energy input for equivalent hot water supply. As well, the test facility plumbing was designed to ensure as 'equal' operating conditions as possible by having both units share a common system for distribution throughout the residence. Unavoidably, some compromises in operation had to be made as no two water heaters can be identical in every respect.

5.0 WATER HEATER INSTALLATION

5.1 Remarks

Both water heater installations were not serviced by the same contractor. As a result the work done on each site differed. One installation saw no difficulties and the work was neat and professional. The second contractor misinterpreted the mechanical drawings and initially installed the heat traps and BTU metering incorrectly. The problems were rectified with a return visit by the contractor and the sites were approved for testing. Installation schematics and pictures are given in Appendix D.

With exception to the heat traps which are a relatively new introduction to normal water heater installation, it should be noted that the problems encountered involved metering and specialized test requirements not normally handled by general contractors. In terms of the basic water heater installations, the scope of work was straight forward with only minor modifications to conventional installation practices.

6.0 MONITORING

6.1 Procedure

In monitoring the equipment, a decision was made to have the respective homeowners cycle the water heaters and record the necessary information as per a specific schedule (See Appendix E). This it was felt would provide a convenient, yet reliable means of cycling the equipment. To ensure consistancy in the operation and recording of data, an operating package was put together and distributed to the homeowners. In addition, Union Gas staff were to inspect the sites regularly and to review the results of the testing with respect to total energy consumptions.

6.2 Metering

The question of metering readability was assessed with respect to the gas submeter. The standard residential meter is graduated to one hundred cubic feet (100 cu. ft.). It was felt that this is inadequate for test purposes and consequently the standard meters were re-equipped with indices readable to the nearest 0.1 cu. ft.. This typically represents a daily reading accuracy of approximately 0.07 percent which in itself is within the inherent accuracy of the meter.

The BTU meters register to the closest 100 BTU's which represents a typical daily reading accuracy of approximately 5.6

percent. The accompanying U.S. gallon register records to the nearest gallon, a typical daily reading accuracy of approximately 3.5 percent based on typical consumption characteristics taken from Union Gas test installations. The electrical meters are standard residential units and register to the nearest KWH. Metering specifications are given in Appendix C.

7.0 CONCLUSIONS

7.1 Remarks

With the installations and commissioning trials completed, the test sites were scheduled to begin operation. To date, both locations have been operating smoothly, with few problems to report.

7.2 Interim Comments on Installations

1. The water heaters appeared to be similar in design and construction as well as in their installation requirements with comparable conventional equipment, thereby posing no related problems in installation. For all practical purposes, any experienced plumbing contractor can be expected to install the improved efficiency water heater.

   The heat traps did pose a problem due to their novelty as a new installation practice, however this problem is not specific to the improved efficiency unit since heat traps are also recommended for conventional installations.

2. The respective units were matched by volumetric output capacity and normalized by setting equal initial delivery temperatures. In actual operation the delivery temperature will vary considerably between units as related to each units' operating characteristics. Inevitably, compromises had to be made in order to accomodate the different characteristics of each water heater. How efficiently a unit maintains the set temperature and the operating costs of each unit are essentially the experimental information desired.

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APPENDIX A

SITE CRITERIA

The following is a list of criteria required of each test site.

1. Natural gas service must be available.
2. The heater must be set at a constant outlet water temperature for the entire test year.
3. The home must be made accessible for inspection by Union Gas given reasonable notice.
4. The use of any other water heating sources will not be allowed.
5. The homeowner must be available to switch water heaters and record the required data, at or about the same time each week.
6. The house must have a minimum of three (3) permanent residents with typical water consumption.
7. The site must have 240 V service with adequate amperage if the house is chosen for installation of an electrical unit.

SITE I GAS/GAS LOCATION

Test Site - Chatham, Ontario

Home Details
- detached, single family house with basement, 1978 construction
- 4 occupants, 2 Adults, 2 young children
- Water outlet temperature set at approx. 57 Deg. C.

Test Unit (Figure Appendix C)
- Gas fired
- John Wood Ltd., Improved Efficiency Unit

Rated
Input = 9.52 KW
Capacity = 151.4 litre

Measured
Input = 9.468 KW
Set Water Temperature = 56 Deg. C.

Existing Unit
- Gas fired
- Fergus GSW Inc., Model 5G40NS, Conventional Unit

Rated
Input = 10.55 KW
Capacity = 151.4 litres

Measured
Input = 10.22 KW
Set Water Temperature = 56 Deg. C.

SITE II GAS/ELECTRIC LOCATION

Test Site - Wheatley, Ontario

Home Details
- Detached, single family with basement, 1961 construction
- 4 occupants; 2 Adults, 2 teenagers
- Water temperature set at approx. 57 Deg. C.

Test Unit (Figure Appendix C)
- Gas Fired
- John Woods Ltd., Improved Efficiency Unit

Rated
Input = 9.52 KW
Capacity = 151.4 litre

Measured
Input = 9.46 KW
Set Water Temperature = 58.3 Deg. C.

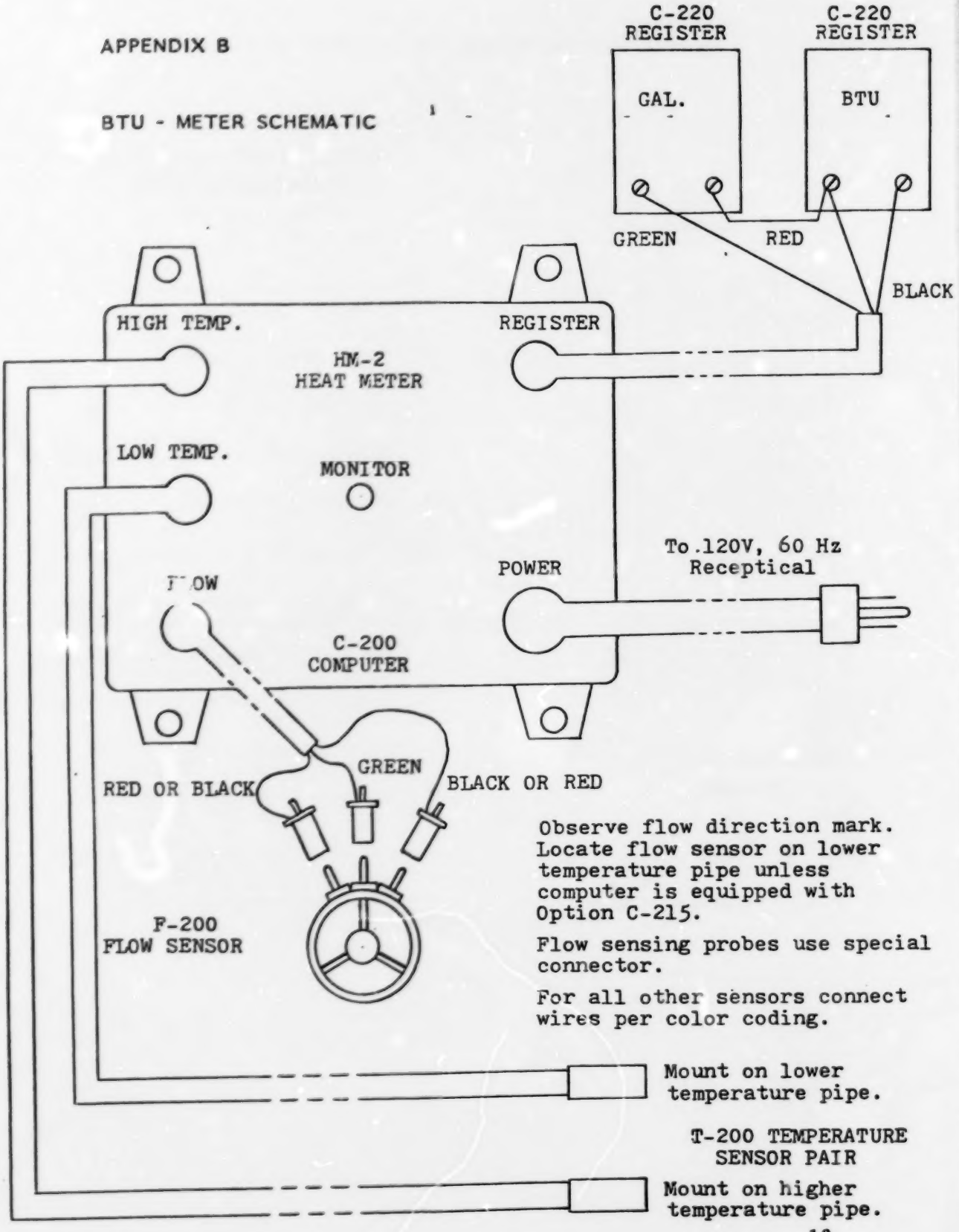
Existing Unit
- Electric
- Ruud Electric conventional unit

Rated
Input = 3.0 KW (total)
Capacity = 151.4 litre

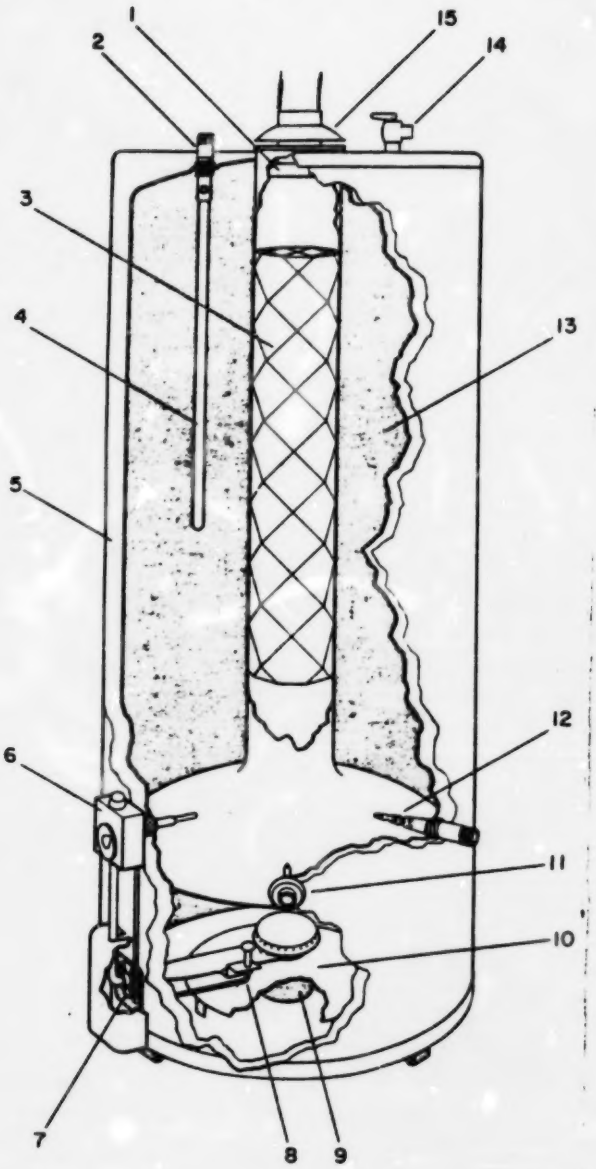
Measured
Input = 3.014 KW
Set Water Temperature = 58.5 Deg. C.

APPENDIX B

BTU - METER SCHEMATIC



WATER HEATER SCHEMATIC (IMPROVED EFFICIENCY)



DESIGN FEATURES OF A NEW WATER HEATER

1. Shield to deflect heat away from top circular weld.
2. Plastic-lined anode/hot water outlet combination fitting.
3. Wide centre flue with special baffles for highest extraction of heat from flue gases.
4. Patented CGRI polarized magnesium anode for maximum protection of tank surfaces.
5. Double thickness insulation to minimize heat losses.
6. Special position of thermostat to reduce stacking.
7. Easily accessible primary air adjustment for combustion tuning.
8. Mini-pilot of stable design and low input to minimize gas consumption on standby.
9. Placement of secondary air entry to maximize preheating of secondary air.
10. Radiation shield to permit installation on combustible floors.
11. Drain combined with zinc probe for verification of corrosion protection.
12. Cold water inlet diffuser for best reliable temperature distribution.
13. Corrosion resistant glass enamel lining.
14. Plastic coated T & P valve for superior safety performance.
15. New draft diverter design to minimize loss of heated room air.

APPENDIX B

METERING SPECIFICATIONS

ELECTRIC METERS

- Type C.F.A. Westinghouse standard meter
- One 115 Volt, 10 amp. nominal
- Readability to 1 KWH

BTU METER

- Model HM-2, 24 V meter (see figure on preceding page)
- Registers accurate to nearest:
    1. One gallon
    2. BTU x 100

GAS METER

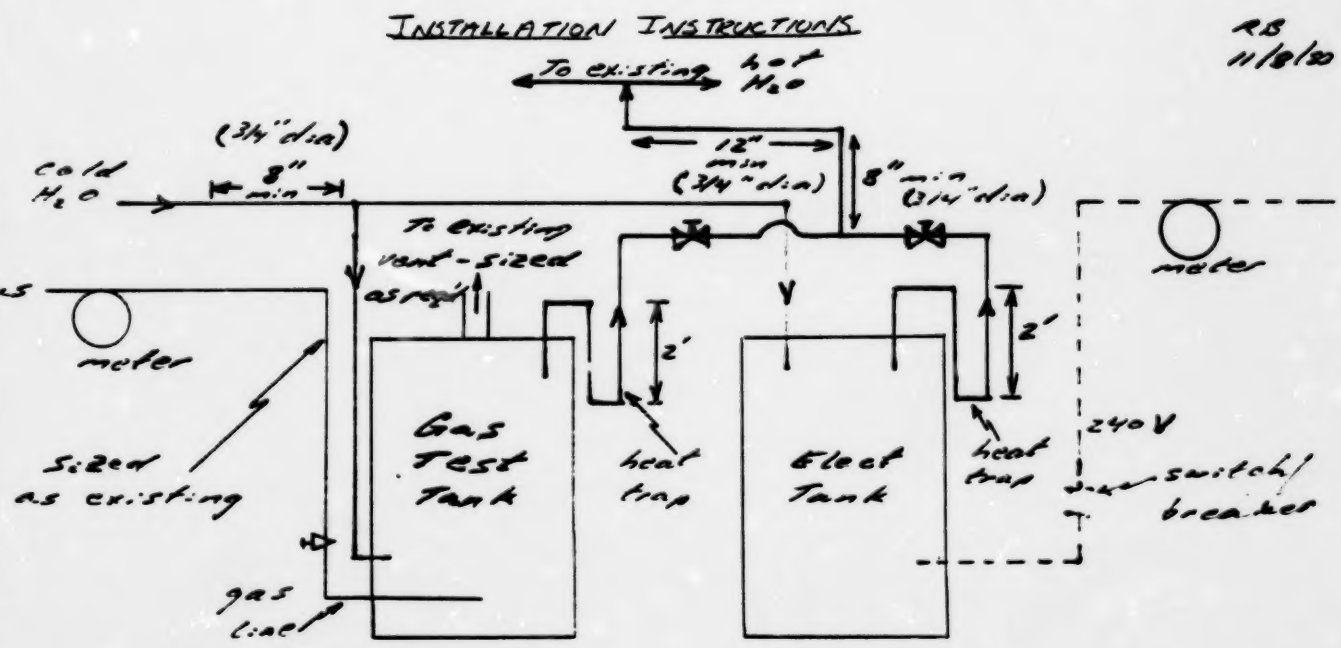
- Canadian Meter Co. Type AL225

Calibrated at;

- 3.143 m^3/hr. air
- Litres computed at temperature of 15.5 Deg. C.
- Equipped with digital index graduated to 0.1 ft^3

APPENDIX C

INSTALLATION INSTRUCTIONS



Note:

- each water heater is to be equipped with a T/P relief valve and down pipe sized as required;

- the gas submeter will be installed by Union Gas - the contractor is however to make provision for the meter;

- 3/4" diameter copper tubing is to be used as indicated. All other tubing is sized as existing;

- the 240 V meter is to be grounded such that it is safe.

Supplied by Union Gas Limited:

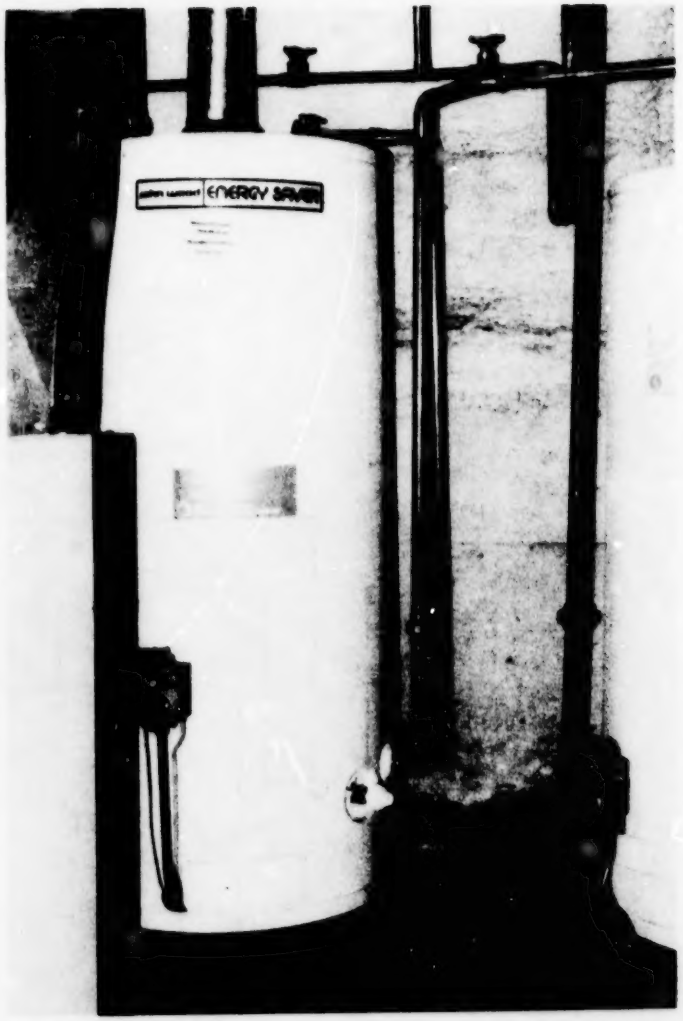
- 240 V. meter
- John Woods gas DHW tank
- electric 240 V. DHW tank
- blank meter head (for spacing of meter location).

APPENDIX D

INSTALLATION DIAGRAMS SITES I AND II

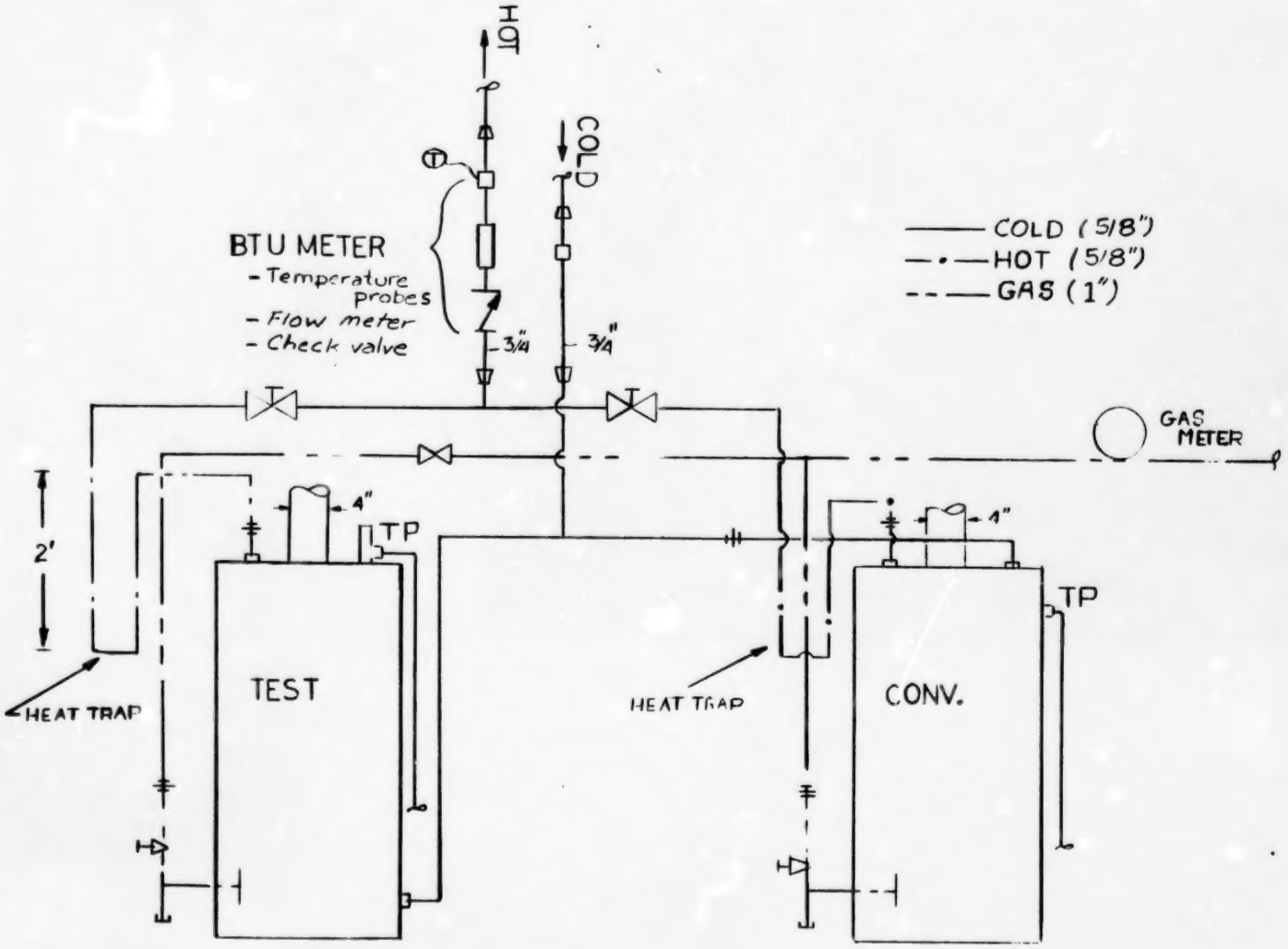
SITE I: GAS/GAS

Site House Construction



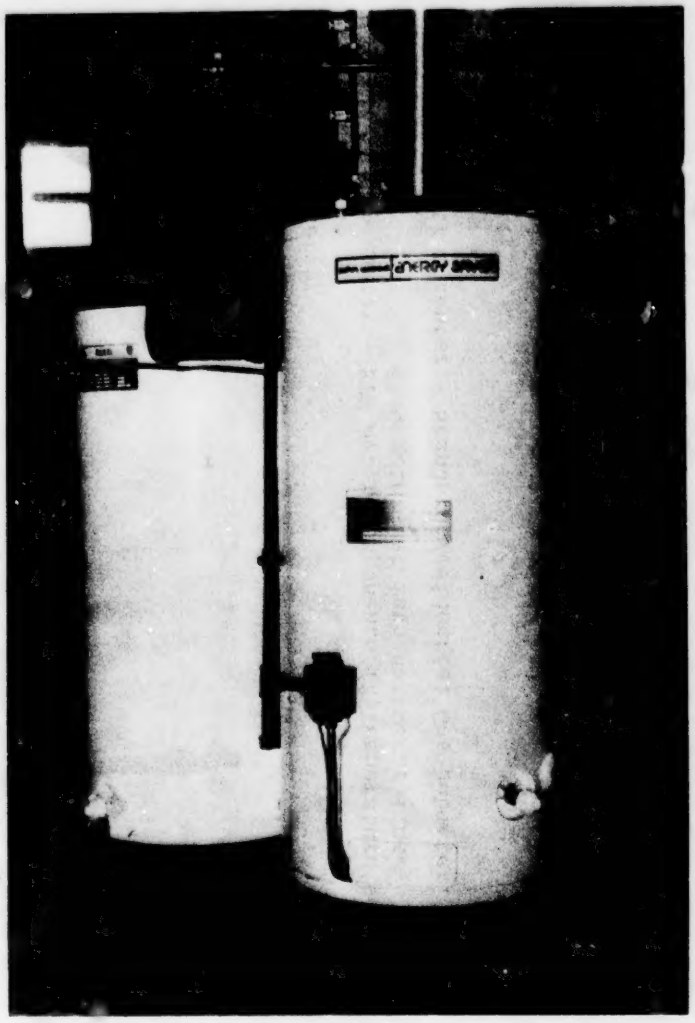
Improved Efficiency Test Unit (John Woods)
with cold water inlet at base.

SITE I GAS/GAS



SITE II: GAS/ELECTRIC

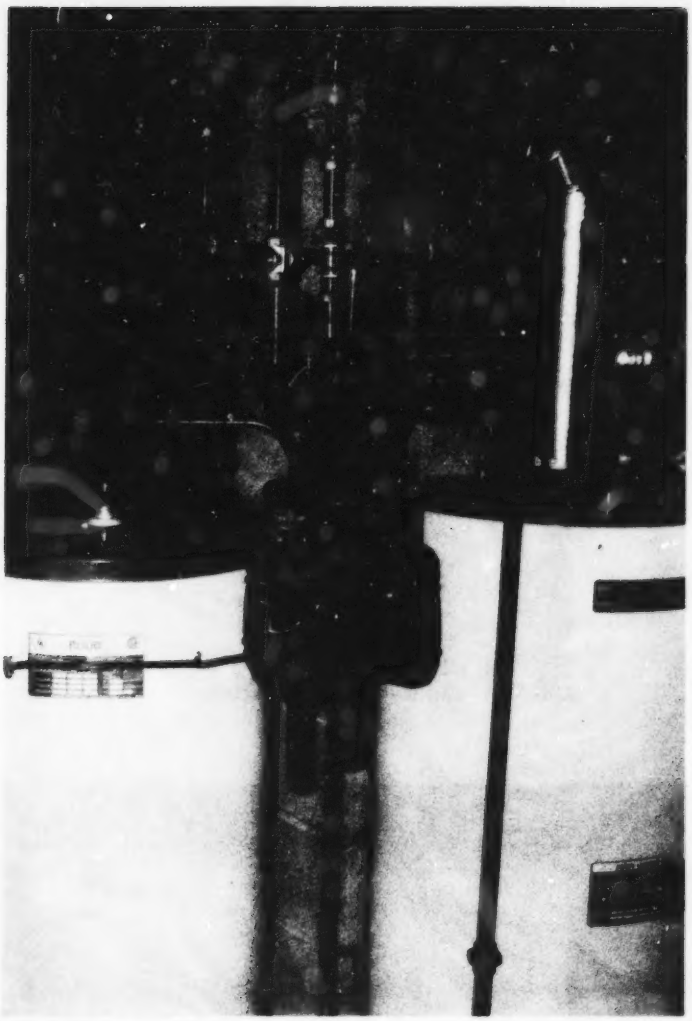
Site House Construction



Left: Conventional electric (RUUD) unit.

Right: Improved Efficiency Gas (JOHN WOODS) unit.

SITE II: GAS/ELECTRIC

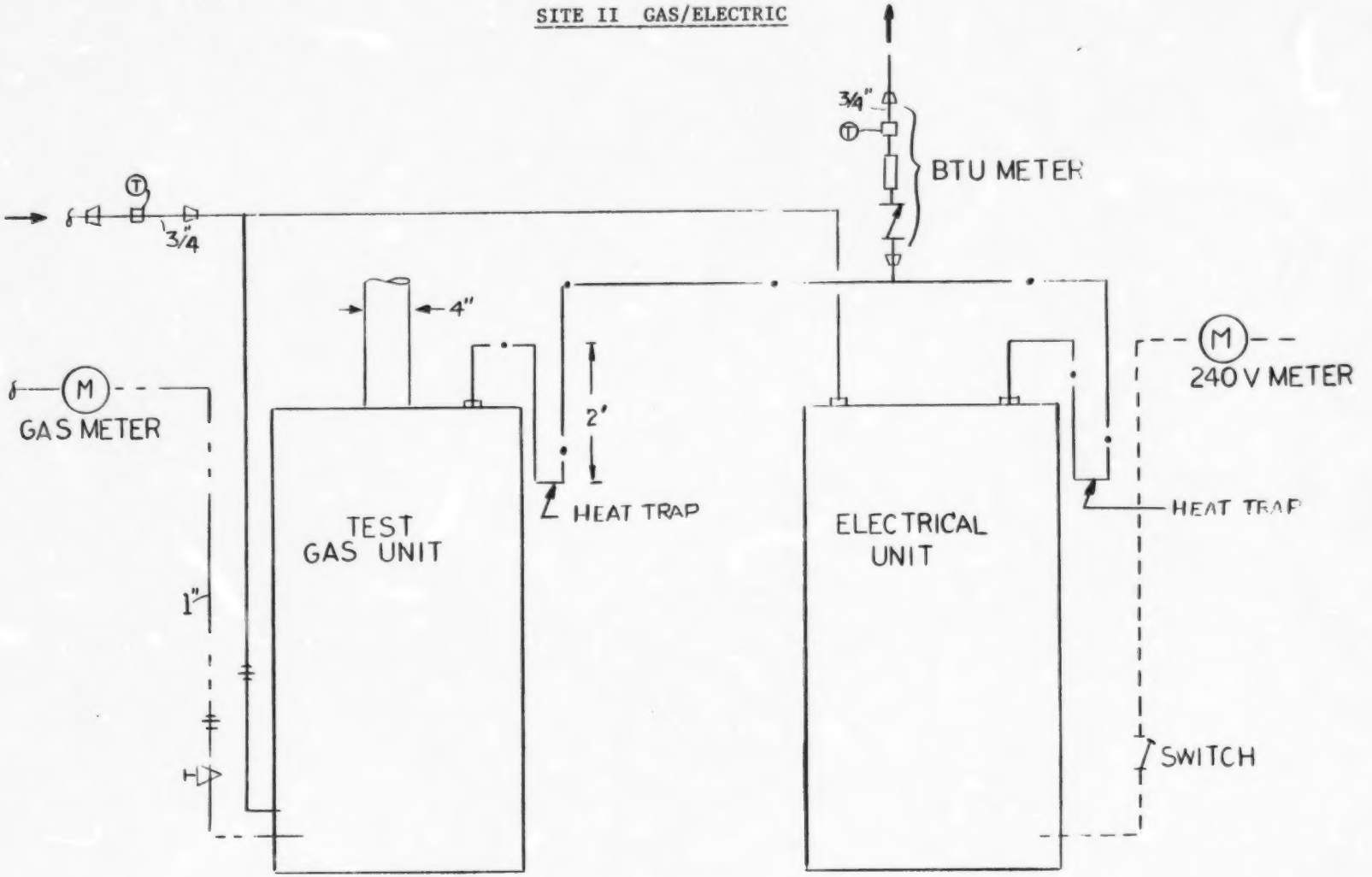


Metering

Top center - BTU meter components (2 Temperature sensors, and flow meter set into hot water line)

Bottom center - Standard residential Gas submeter.

SITE II GAS/ELECTRIC



APPENDIX E

DATA RECORDING INSTRUCTIONS AND TABLE.

WATER HEATER OPERATION

1. General Instructions

   i) The flip/flop changes are to be made on a weekly basis, at or near the same time each week (preferably between 7 and 11 p.m.).

   ii) In alternating between the test unit and the conventional unit, a data sheet (following) must be completed at the beginning and end of each period of operation.

   iii) Care must be taken in correctly reading the meters -

   iv) A warm up period of 1 hr. must be observed before preliminary data readings are taken.

OPERATING STEPS:

- Conventional Gas Unit (FERGUS GSW)

   i) Turn gas OFF to test unit and record data for the test unit.

   ii) Turn gas ON to conventional unit and ignite pilot following manufacturer's instructions.

   iii) CLOSE hot water valve on test unit side.

   iv) OPEN hot water valve on conventional unit side.

   v) Allow the unit to operate at least one full hour before taking preliminary data recordings.

- Test Gas Unit (John Woods)

   i) Record data for the conventional unit.

   ii) CLOSE hot water valve on conventional unit side.

   iii) OPEN hot water valve on test unit side.

   iv) Turn gas ON to test unit and ignite pilot following manufacturer's instructions.

   v) Allow the unit to operate at least one hour before taking preliminary data recordings.

WORK SHEET
TITLE: HIGH EFFICIENCY WATER HEATER STUDY
LOCATION:
PERIOD:

		OPERATION		INPUT	DELIVERY	
				CONSUMPTION	BTU METERING	
DATE D/M	TIME HR.:MIN.	CONV. GAS	TEST GAS	GAS (CU. FT.)	BTU x 100	U.S. GALLONS
						22

APPENDIX F

STUDY COSTS

Regular Installation Costs

Two (2) John Woods water heaters	2 x ($252.00)	$504.00
Installation Charge	2 x ($125.00)	$250.00
	TOTAL	$754.00

Study Related Costs

One electrical unit	$174.95
Two (2) BTU Meters 2 x 500.30 + $113.15 (Duty + Tax) =	$1,226.90
Two (2) Gas indexes 2 x (36.16)	$72.32
One (1) Electric meter and meter bases	$24.08
Installation of equipment	$800.00
Electrical upgrading for Electric unit	$750.00
TOTAL	$3,048.25

NOTES

1. The purchase prices of the water heaters are approximate in that they represent a typical retail price; actual prices may vary. These prices include freight and taxes.
2. Installation costs as quoted by the contractor include all labour, materials and taxes.
3. Costs are as of this writing and subject to change upon receipt of all invoices.